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Automatic Real Time Auditorium Power Supply Control using Image Processing

Venkatesh K[1]and Sarath Kumar P[2]
1 Department of Electronics and Communication Engineering, Kamaraj College of Engineering and Technology, Virudhunagar, India
Email: vivekkvenkat@gmail.com
2 Department of Electronics and Communication Engineering, Kamaraj College of Engineering and Technology, Virudhunagar, India
Email: smaartsarath@gmail.com

***Abstract* —One of the major problems in the most populated and developing countries like India, is Energy or Power crisis. Hence, there is a pressing need to conserve power. There are many simple ways to save electricity, like using the electric and electronic gadgets whenever and wherever needed and switching them off, while not in use. But in places such as large auditoriums and meeting halls, there will be a fan or an Air-conditioner keeps running in unmanned area too, even before the people arrive. This contributes to a considerable amount of electricity wastage. There are many ways to prevent this wastage, like, installing IR sensors to detect people etc. These methods are quite costlier and complex for larger areas. Hence, here we propose a new method of controlling the power supply of auditoriums using, Image Processing. Here first we take a reference image of an empty auditorium and any change in that reference image is detected and then according to that change respective equipments alone are turned on. Thus power wastage is controlled. This is dual usage system in which a camera is used for detecting people as well as surveillance purposes. This is very simple, efficient and cheaper technique to save energy. Another big advantage is, we can extend this up to applications like home automation etc.**

***Keywords* — Image Partitioning, Edge Detection, Image Subtraction, Threshold Determination**

I.INTRODUCTION

Often, we may have came across a scenario that in places such as large auditoriums or halls, electric equipments like, fans, lights or air conditioners are running, even if there is no people. They are operated manually. Moreover, in some cases, some areas may be unfilled. But even in those areas those electric equipments are running meaninglessly. This is because, every time manually turning on and off a fan in accordance with the arrival of people, is an uncomfortable task. To avoid this, they are turned on prior to the arrival of people, as a precaution. This causes considerable wastage of power. Hence an efficient system that automatically controls the power supply of this kind of places is in a demand. Current automatic controlling techniques use Infrared sensors to detect people. For simple setup, the operation depends on the count [1]. But we cannot find the places which are unoccupied. Large array of IR sensors are needed to be installed in places with larger area. Hence installation cost as well as the circuit complexity increases. As everyoneknows, IR is harmful for human beings. Hence, here we propose a new method to meet this demand,

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using a famous technique called, Image Processing.

Using this technique we monitor the changes in the auditorium through sequence of images and according to that the power supply is controlled. Image processing is a form of signal processing for which the input is an image, and the output may be either an image or, a set of characteristics or parameters related to the image [2]. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. The implementation of power supply control using image processing is relatively very simple. The empty image of the auditorium is taken as a reference image, using a digital camera in an elevated view. The image is converted to gray and enhanced using image enhancement techniques. Now edge detection is done. Similarly the captured real time image is enhanced and edge detected. These two images are compared and using the comparison results, respective control signals are generated using a hardware prototype. The reference and real time images undergo the following processes starting from their acquisition, Gray conversion, Partitioning, Edge detection, Comparison and finally generating the control signals.

II. METHODOLOGY

The General framework is given as a block diagram in Fig. 1.

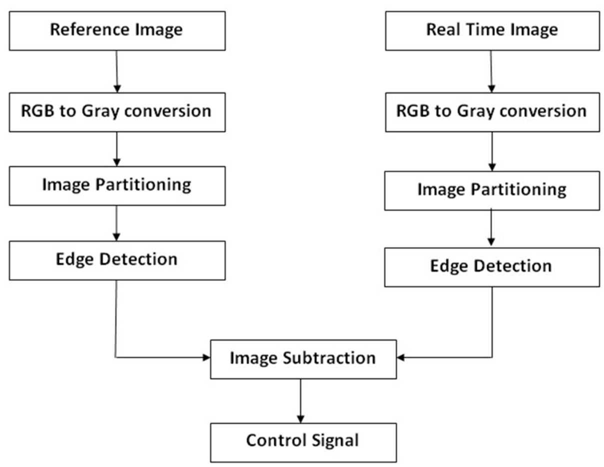

Figure 1. General Framework

For convenience, in this entire paper, we consider a class room instead of an auditorium for an example.

A. Image Acquisition

The first stage is the image acquisition. After that any processing techniques can be applied to it. Image acquisition means creating digital images from a physical scene. It includes processing, compressing, storing, printing and displaying the images [2]. The most usual method is by digital photography with a digital camera but other methods like using image sensors can also be employed. Here we go with the digital camera. The camera should be installed in a perfect place so that it covers the entire auditorium or Hall. The camera is interfaced with a computer or a micro-controller. First image of the auditorium is captured, when there are no people. This empty auditorium's image is saved as reference image at a particular location specified in the program (Fig. 2a). The images resolution may vary from camera to camera. But a fixed resolution must be maintained for an application. In this illustration, the image resolution is of width 2592 pixels and height 1944 pixels. Note that, reference image is taken only once, whereas the real time images are captured in certain intervals of time. Here we take the real time images in the interval of 10 seconds (Fig. 2b). In this example case a person occupies a seat in the last row. Here the camera angle is a very important parameter. Aerial view is the most recommended one. And camera should be fixed and stationary one, throughout the process. The captured images are fed as inputs to the main program through certain algorithms.

Figure 2a.Reference Image

Figure 2b. Real Time Image

The real time image captured is a color image (RGB image). But grayscale images are comfortable for processing. A Grayscale image contains each pixel as a single sample. In other words it carries only intensity information. These images are also known as black-and-white images, and that are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. The gray scale image contains image components with 256 intensity levels ranging from 0 to 255. RGB to Gray conversion is done for both the reference and captured images (Fig. 3a and Fig. 3b). The purpose of this image intensity conversion is the analysis of the image which is easy for processing in gray scale mode than in the RGB mode.

Figure 3a.Grayscale Reference Image

Figure 3b.Grayscale Real Time Image

B. Image Partitioning

An image is understood as a collection of regions that totally covers it (a partition). Regions are homogeneous in the selected feature space and connected in the image space. Such an image representation enables region-baseduser interaction. In it, the user can interact with the underlying partition(s) that represent the image [3]. After partitioning the features are the regions can be parallel processed. Now in our case, auditorium is installed with many fans and lights. Each fan or a light has its own coverage area. According to the coverage area we split the image into many cells, with each cell is simply the area covered by a fan. This is because; during the image comparison we have to know the place where the humans exist. So initially the cells are split and given a unique name or label. In this example if a hall has 4 fans, we will divide the image into four regions (Fig. 4). Each region is the coverage area of each fan. Using these regions further processing is carried out. Totally there are twelve regions. But out of them only four regions are going to be occupied by humans. Hence those four regions are alone considered. They are indicated by numbers in the Fig.4. The resolutions for these cells are given in the TABLE 1. These are the cells that are going to be processed. Note that both the reference and real time images are partitioned in a same manner. Field study is required to know the exact coverage areas. These areas are carefully specified in the main program.

TABLE I. RESOLUTION FOR VARIOUS CELLS

Cell Name	Width (Pixels)	Height (Pixels)	Corresponding Equipment
Cell 1	370	1140	Fan 1
Cell 2	370	1022	Fan 2
Cell 3	880	1140	Fan 3
Cell 4	880	1022	Fan 4

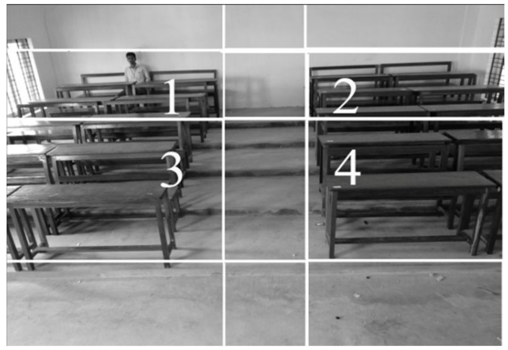

Figure 4. Image Partitioning Illustration

C. Edge Detection

Edge detection is a basic tool in image processing used for feature detection and attributes extraction. The edge is detected by any abrupt change in intensity levels of an image. Using this technique the amount of data to be analyzed is reduced and hence the response time will be reduced. The main objective of edge detection is to find out the variations in the real time captured image from the reference image. There are many detectors for edge detection like sobel, prewitt, canny etc. Here we go with the canny edge detector. It is one of the most widely used algorithms. First, it smoothens the image and detects the image gradient to highlight regions with high spatial derivatives. It then tracks along these regions to suppress any pixel that is not at the maximum. Finally, through hysteresis, it uses two thresholds and if the magnitude is below the first threshold, it is set to zero. If the magnitude is above the high threshold, it is made an edge and if the magnitude is between the two thresholds, it is set to zero unless there is a path from this pixel to a pixel with a gradient above the second threshold. That is to say that the two thresholds are used to detect strong and weak edges, and include the weak edges in the output only if they are connected to strong edges [4]. Here, we find edge detected images for each and every cell. A typical edge detected cell in both reference image and real time image is shown in the Fig. 5a and Fig. 5b respectively. When the images are directly taken for any processing, the analysis time and the process data will be very high. But, here after the edge detection, only the edges appear in the images. So the calculation time will be reduced.

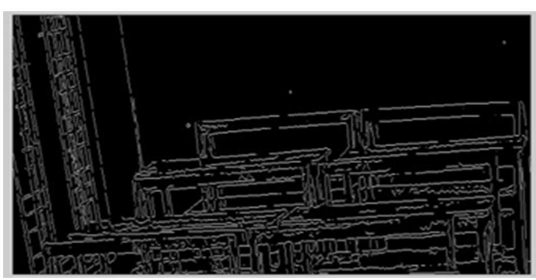

Figure 5a. Edge Detected Reference Image of Cell 1

Figure 5b. Edge Detected Real Time Image of Cell 1

D. Image Comparison

In this step, the two edge detected images are compared by merely subtracting and the intensity values for the entire new image is calculated. Image subtraction is a type of Image segmentation. We need to extract the human shape from the background. Hence, the real time images are subtracted from the reference image. This subtraction results in indication of the places which are modified. In other words we can say that, the regions which are occupied by humans are obviously indicated (Fig. 6). The summation of all values in the resultant matrix is then obtained.

E. Generating Control Signals

Now all the changes are identified. The cells which are occupied by humans will be detected in the above step. The modified values are summed for each cell separately. If this sum of a particular cell exceeds the

threshold value then the fan or light corresponding to that cell is turned ON. The threshold value determination is the important process here. Various test cases are considered and the threshold value must

Figure 6. Subtracted Image

be carefully determined. Generally it is should be the minimum change that can be detected when a human being enters the cell. The threshold values vary from cell to cell. The cells that are closer to the camera will have larger threshold values than that of the cells that are farther. Here for the four cells the threshold values vary from 1500 to 2500. This controlling can be done using separate microcontroller circuitry interfaced with the programming system.

III. RESULTS AND DISCUSSIONS

The various results are compared with some test cases (Figures 7a, 7b, 7c and 7d). Figures 8a, 8b, 8c and 8d are the respective edge detected subtracted images. The probability of seating arrangement people is very vast in numbers. They can either occupy the areas which are closer the camera or the areas that are farther from the camera. When people occupy the cells at the bottom of image matrix (cells 3 and 4) the threshold value will be more. One the other hand if people occupy the cells in the top of image matrix (cells 1 and 2) then the threshold level will be lesser. This is because; when a person occupies a seat that is farther to the camera, his size will be smaller in the captured image. Similarly, if he occupies a seat that is nearer to the camera, his size will be larger in the image. The minimum change when a human being enters the cell can be detected and the minimum threshold level must be found out. Refer TABLE 2 for the threshold values of these cells. In Fig. 7a a man occupies the cell 1. His presence will exceed the threshold value in image subtraction and hence the fan 1 will be turned ON (TABLE 2 and TABLE 3). Similarly in Fig. 7b all the cells are occupied resulting in switching all the four fans ON. If a person occupies a place near the frontiers of two cells, so that his presence is detected in two cells, then both the fans corresponding to those cells are turned on, with the summation exceeding the threshold value. Figures 7c and 7d are examples for this case. Fan 1 and fan 3 will be turned ON for these cases.

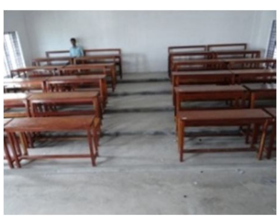

Figure 7a. Cell 1 is occupied

Figure 7b. All the cells are occupied

Figure 7c. Cell 3 is occupied

Figure 7d. Group of people occupying cell 3

Figure 8a.Subtracted Image for Fig. 7a

Figure 8b.Subtracted Image for Fig. 7b

Figure 8c.Subtracted Image for Fig. 7c

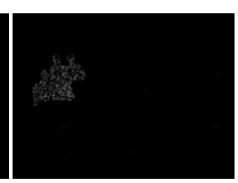

Figure 8d. Subtracted Image for Fig. 7d

Here various test images are given as inputs as real time images and the minimum threshold for each cells have be tabulated as follows:

TABLE II. THRESHOLD VALUES FOR VARIOUS CELLS

Cell Number	Minimum Estimated Threshold Value
Cell 1	1500
Cell 2	1500
Cell 3	2500
Cell 4	2500

TABLE. III. OBTAINED SUMMATION VALUES FOR VARIOUS CELLS

Test Figures Name	Summation Values for				Fans Turned ON
	Cell 1	Cell 2	Cell 3	Cell 4	
Fig. 7a	2557	0	0	0	Fan 1
Fig. 7b	29248	9050	13413	10686	Fan 1, Fan 2, Fan 3 and Fan 4
Fig. 7c	8060	0	5478	0	Fan 1 and Fan 3
Fig. 7d	47703	0	34987	0	Fan 1 and Fan 3

IV. CONCLUSION

The study showed that image processing is a better technique to control the power supply in the auditoriums. It shows that it can reduce the wastage of electricity and avoids the free running of those electrical equipments. It is also more consistent in detecting presence of people because it uses real time images. Overall, the system is good but it still needs improvement to achieve a hundred percent accuracy. If achieved, then we can extend this application to many places like theaters and even for home automation.

V. FUTURE WORK

The main drawback with this system is that, it can be used only for the places whose orientation or arrangement of seats never changes. But we can overcome this by resetting the reference images whenever the arrangement is altered. The main program needs not to be altered. Another way of overcoming this limitation is using the face detection techniques. It is expected to give much flexibility and simplicity to the overall system.

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